CLAIMS

1. A water heater apparatus, comprising:

a water conduit having an inlet and an outlet;

a primary heat exchanger, having a water side defining a portion of the water conduit;

a burner operatively associated with the primary heat exchanger for heating water in the water side of the primary heat exchanger; and

a variable flow blower for providing pre-mixed combustion air and fuel gas to the burner at a controlled blower flow rate within a blower flow rate range.

2. The apparatus of claim 1, further comprising:

a first water temperature sensor for sensing water temperature at a location along the water conduit; and

a controller, operatively associated with the temperature sensor and the blower, for controlling the flow rate of the blower in response to the water temperature sensed by the sensor.

3. The apparatus of claim 2, wherein:

the location of the water temperature sensor is adjacent the outlet of the water conduit.

4. The apparatus of claim 2, wherein:

the location of the water temperature sensor is adjacent the inlet of the water conduit.

5. The apparatus of claim 2, wherein:

the controller includes a water temperature set point system.

6. The apparatus of claim 2, further comprising:

a recirculation conduit connected to the water conduit downstream and upstream of the primary heat exchanger;

a recirculation valve disposed in the recirculation conduit; and

the controller being operatively associated with the recirculation valve for varying a position of the recirculation valve.

7. The apparatus of claim 6, further comprising:

a second water temperature sensor for sensing water temperature upstream of the primary heat exchanger; and

the controller is operatively associated with the second water temperature sensor for varying the position of the recirculation valve in response to the water temperature sensed by the second water temperature sensor.

8. The apparatus of claim 1, wherein the variable flow blower comprises:

an electric motor; and

a variable frequency drive which varies the speed of the electric motor and the flow rate of the blower by varying a frequency of an electrical power signal provided to the electric motor.

9. The apparatus of claim 1, further comprising:

a recirculation conduit connected to the water conduit downstream and upstream of the primary heat exchanger;

a recirculation valve disposed in the recirculation conduit;

a water temperature sensor for sensing water temperature at a location along the water conduit; and

a controller, operatively associated with the temperature sensor and the recirculation valve, for varying a position of the recirculation valve in response to the temperature sensor to maintain the temperature of water entering the

primary heat exchanger above a pre-determined value to prevent condensation of combustion products in the primary heat exchanger.

10. The apparatus of claim 9, further comprising:

a secondary heat exchanger in heat transfer relationship with the water conduit upstream of the primary heat exchanger; and

a combustion gas conduit communicating combustion products from the burner and primary heat exchanger to the secondary heat exchanger.

11. The apparatus of claim 1, further comprising:

a transition chamber for mixing the combustion air and fuel gas upstream from the blower.

12. The apparatus of claim 11, further comprising:

a ratio gas valve for providing fuel gas to the transition chamber at a variable gas rate in response to the blower flow rate to maintain a pre-determined air to fuel ratio over the blower flow rate range.

13. The apparatus of claim 1, further comprising:

a gas valve for providing fuel gas to the blower at a variable gas rate in response to the blower flow rate to maintain an air to fuel ratio over the blower rate range.

14. The apparatus of claim 1, wherein:

the blower flow rate is continuously variable within the flow rate range.

15. The apparatus of claim 14, wherein:

the blower flow rate range provides a heater turn down ratio of at least two to one.

16. The apparatus of claim 15, wherein:

the blower flow rate range provides a heater turn down ratio of at least four to one.

17. A water heater apparatus, comprising:

a heat exchanger having a water flow passage defined therethrough;

a burner operatively associated with the heat exchanger for heating the heat exchanger to heat water flowing through the water flow passage;

a mixing chamber for mixing combustion air and fuel gas;

an air supply duct connected to the mixing chamber;

a gas supply line connected to the mixing chamber;

a blower having a blower inlet connected to the mixing chamber for receiving pre-mixed combustion air and fuel gas from the mixing chamber, and having a blower outlet connected to the burner for providing pre-mixed combustion air and fuel gas to the burner;

a variable speed drive connected to the blower for varying a blower flow rate of pre-mixed combustion air and fuel gas provided by the blower to the burner; and

a gas control valve, disposed in the gas supply line, for controlling a gas flow rate supplied to the mixing chamber in response to the blower flow rate.

18. The apparatus of claim 17, further comprising:

a gas shut off valve disposed in the gas supply line in series with the gas control valve.

19. The apparatus of claim 17, wherein:

the variable speed drive includes an electric drive motor; and

the blower includes a gas containment fan which is sealed from the electric drive motor.

20. The apparatus of claim 17, wherein:

the gas control valve is a ratio valve which is responsive to a pressure differential associated with the blower.

21. The apparatus of claim 17, wherein the variable speed drive comprises:

an electric drive motor connected to the blower for driving the blower; and

a variable frequency drive for varying a speed of the electric drive motor by varying a frequency of an alternating current electrical signal provided to the electric drive motor.

22. The apparatus of claim 17, wherein:

the burner includes a stress free flame attachment surface capable of operating over a turn down ratio of at least two to one.

23. The apparatus of claim 22, wherein:

the burner includes an outer burner layer formed of woven flexible heat resistant fabric which defines the stress free flame attachment surface.

24. The apparatus of claim 17, further comprising:

a temperature sensor disposed in the water flow path; and

a control system, operatively associated with the temperature sensor and the variable speed drive, for controlling the blower flow rate in response to a water temperature sensed by the temperature sensor.

25. The apparatus of claim 17, further comprising:

a secondary heat exchanger located upstream of the first heat exchanger, so that water to be heated first flows through the secondary heat exchanger and then flows through the first heat exchanger; and

a combustion gas duct connected between the burner and the secondary heat exchanger so that combustion products from the burner which have passed the first heat exchanger are directed past the secondary heat exchanger before being exhausted from the water heater apparatus.

26. The apparatus of claim 17, further comprising:

a recirculating water conduit bypassing the heat exchanger;

a recirculating control valve disposed in the recirculating water conduit;

a temperature sensor located adjacent an inlet of the water flow passage of the heat exchanger; and

a control system for controlling a position of the recirculating control valve in response to sensed water inlet temperature to the heat exchanger, so

that the water inlet temperature is maintained high enough to prevent condensation of combustion products from the burner on the heat exchanger.

27. A water heater apparatus, comprising:

a burner;

a primary heat exchanger having an exterior surface exposed to the burner for receiving heat from the burner, and having an inner flow path for flowing water through the heat exchanger, the flow path having a water inlet and a water outlet;

a recirculation conduit communicating the water outlet with the water inlet and bypassing the heat exchanger;

a recirculation valve disposed in the recirculation conduit;

a water temperature sensor disposed in one of the inner flow path and the recirculation conduit; and

a controller, operably associated with the temperature sensor and the recirculation valve, for varying a position of the recirculation valve in response to the water temperature sensor.

28. The apparatus of claim 27, wherein:

the water temperature sensor is located adjacent the water inlet to the inner flow path of the heat exchanger.

29. The apparatus of claim 27, wherein:

the controller maintains the water temperature at the water inlet to the inner flow path of the heat exchanger at or above a selected temperature sufficient to prevent condensation of combustion products from the burner on the exterior surface of the heat exchanger.

30. The apparatus of claim 29, wherein the selected temperature is at least 130°F.

31. The apparatus of claim 27, further comprising:

a secondary heat exchanger located upstream of the primary heat exchanger so that incoming water flows first through the secondary heat exchanger and then through the primary heat exchanger; and

a combustion conduit for directing combustion products from the burner and the primary heat exchanger to the secondary heat exchanger, so that water flowing through the secondary heat exchanger is preheated by the combustion products before the water flows into the primary heat exchanger.

32. The apparatus of claim 31, wherein:

the secondary heat exchanger is a condensing heat exchanger which allows condensation of the combustion products on the exterior of the secondary heat exchanger.

33. The apparatus of claim 32, wherein:

a surface of the secondary heat exchanger exposed to combustion products is coated with a corrosion resistant coating to prevent corrosion resulting from the condensation.

34. A method of heating water, comprising:

(a) providing a burner having an operative range of energy output rates varying from an upper limit to a lower limit;

(b)mixing combustion air and fuel gas to create an air and fuel mixture;

(c) receiving the air and fuel mixture in an inlet of a variable output blower and delivering the air and fuel mixture from the blower to the burner;

(d) heating a stream of water of a water heating system with heat input from a heat exchanger which receives heat from the burner;

(e) monitoring a parameter of the water heating system; and

(f) varying the output of blower in response to the monitored parameter and thereby varying the energy output rate of the burner and the heat input to the stream of water.

35. The method of claim 34, further comprising:

upon start up of the burner, limiting the output of the blower to a selected fraction of a maximum output of the blower, so that the burner starts up at a selected reduced energy output rate less than its upper limit.

36. The method of claim 35, further comprising:

after start up of the burner, operating the burner at a selected reduced energy output rate for an interval, then varying the blower output.

37. The method of claim 34, further comprising:

controlling a fuel gas flow rate in response to the output rate of the blower, and thereby maintaining a constant air to fuel ratio received by the blower.

38. The method of claim 34, further comprising:

maintaining a fuel gas flow rate proportional to a combustion air flow rate, and thereby controlling an air to fuel ratio of the mixture received by the blower.

39. The method of claim 34, wherein:

in step (e) the monitored parameter is water temperature.

40. The method of claim 34, wherein step (f) comprises:

varying a speed of an electric drive motor driving the blower.

41. The method of claim 40, wherein:

the speed of the electric drive motor is varied by varying a frequency of an electric power signal provided to the electric drive motor.

42. The method of claim 40, further comprising:

isolating the air and fuel mixture in the blower from the electric drive motor.

43. The method of claim 34, further comprising:

preventing condensation of combustion products from the burner on the heat exchanger by recirculating water exiting the heat exchanger back to a

water inlet of the heat exchanger until the temperature of water entering the heat exchanger exceeds a pre-determined minimum inlet temperature.

44. The method of claim 34, further comprising:

pre-heating inlet water flowing to the heat exchanger by first flowing the inlet water through a secondary heat exchanger; and

after combustion products from the burner have passed the first heat exchanger, flowing those combustion products past the secondary heat exchanger to extract additional heat energy from the combustion products.

45. A method of heating water, comprising:

(a) providing a heat exchanger having a water flow path defined therethrough, the flow path having a water inlet and a water outlet;

(b) heating the heat exchanger with a burner;

(c) flowing water through the water flow path of the heat exchanger to heat the water;

(d) monitoring temperature of the water;

(e) when the monitored water temperature is below a lower limit temperature, recirculating at least a portion of the heated water exiting the water outlet back to the water inlet; and

(f) thereby maintaining water temperature within the heat exchanger above the lower limit temperature and preventing condensation of combustion products from the burner on an exterior of the heat exchanger.

46. The method of claim 45, wherein step (e) comprises:

changing a position of a recirculation valve in response to the monitored water temperature.

47. The method of claim 45, wherein step (d) comprises:

monitoring temperature of the water at the water inlet to the water flow path of the heat exchanger.

48. The method of claim 45, wherein the lower limit temperature is at least 130°F.

49. The method of claim 45, further comprising:

pre-heating inlet water flowing to the heat exchanger by first flowing the inlet water through a secondary heat exchanger; and

after combustion products from the burner have passed the first heat exchanger, flowing those combustion products past the secondary heat exchanger to extract additional heat energy from the combustion products.

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